# Queckenstedts's test

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## SUMMARY

Isovolumetric CSF pressure recording provides a very accurate analogue of hydrodynamic events occurring in the subarachnoid space. This study was undertaken to determine normal parameters of CSF pressure rise and fall on jugular compression for electromanometric CSF pressure measurement and to assess the usefulness and clinical validity of this method.

I. Queckenstedt's test - the use of bilateral jugular compression in the detection of a spinal canal obstruction - has been a useful adjunct to neurological diagnosis for more than 50 years. The simple open-end water manometer has hitherto served as the device for visualizing CSF pressure variations and it remains in clinical use, despite many attempts at technical refinement. More sophisticated manometry, especially the isovolumetric method, has contributed substantially to the understanding of the hydrodynamics of the CSF spaces.

The Monro-Kellie doctrine, viz. that the sum of the volumes of blood, CSF and brain substance within the skull is constant, is still a fundamental basis of CSF hydrodynamics. The problems of CSF secretion and absorption, dural distensibility and elasticity, and the relationship between CSF pressure and venous pressure have been greatly elucidated by the investigations of Weed, Flexner, Masserman and Bering. However, the particular hydrodynamic events occurring on jugular compression have received but scant attention: only Verjaal, Taylor and to a lesser extent Gilland advanced theories explaining the mechanism of Queckenstedt's test. One of the most valuable advances in the detection of spinal subarachnoid obstruction has been the introduction of functional manometry by Kaplan and Kennedy. By its means intermittent subarachnoid obstruction in the cervical area can be detected, and lesions of the bony cervical canal inflicting damage on the spinal cord better understood. Höök,

Lidvall and particularly Gilland were the first to report on the use of electromanometric equipment for spinal block detection.

II. Since 1965 electromanometric CSF pressure recording has been carried out by the author in the Department of Neuroradiology of the University Hospital of Groningen. A puncture needle, after introduction into the dural sac, is connected to a pressure transducer by means of flexible tubing and the system filled with distilled water; no CSF leaves the subarachnoid space. The CSF pressure variations are transmitted via the fluid-filled tubing to a diaphragm in the pressure transducer. Minimal diaphragmatic movements cause small changes in the distance between two plates forming a capacitor; these changes in capacitance are detected by electronic circuitry and recorded by means of an ink-writing recorder. Testing of the electromanometric equipment revealed that its fidelity within a range of 0-7 cps was undistorted - a requirement generally accepted as adequate.

A total of 104 consecutive CSF pressure recordings, divided into 2 series, was analysed with respect to the CSF pressure changes on jugular compression in the various head positions. In a limited number the CSF pressure changes occurring on abdominal compression, on Valsalva's manoevre, and following withdrawal of 10 cm.$^3$ CSF were studied on the tests mentioned. The CSF pressure rise and fall were determined. Basic pressure, maximal pressure, closing pressure and pulse amplitude were measured. The shape of the pressure curves was evaluated according to a preestablished classification. The results were matched with the findings of neuroradiological examinations and surgical procedures. Most information was analysed by a digital computer.

III. The classical open-end manometer shows rise and fall of the CSF level on Queckenstedt's test within a matter of seconds. The isovolumetric method monitors these pressure variations more faithfully: under normal circumstances a rise or fall occurs in less than 0.5 second. Cineradiological recording of the behaviour of myelographic contrast medium on jugular compression in the cervical region confirmed this, in that very abrupt movements of the contrast column were demonstrated. Apparently CSF is displaced, which is possible only if the dural sac is distensible. The properties of the dural sac are of utmost significance in this connection. Normally it is under a certain stretch and tension. Evidence of the elasticity and distensibility of the dura was found, i.a. in the moderately damped cardiac pulsations present in the CSF, the amplitude of which diminishes on lowering of the CSF pressure. It became apparent that the logarithm of the CSF pressure was linear on witdrawal of CSF in equal volumes, as was the logarithm of CSF pressure on jugular compression; both these lines were found to run parallel. However, this linearity disappeared after withdrawal of a certain volume of fluid, indicating that the factor of dural elasticity had ceased to operate and the dura was completely relaxed. From this point it was reasoned that events in the epidural space determined the course of further diminutions in pressure.

The normal CSF pressure curve on jugular compression shows an abrupt change in the rise, the steep phase being followed by a more gradual one. This sudden transition can be explained by the role of the collateral venous circulation. Jugular compression causes an increase in the intracranial blood volume. CSF is displaced caudally and increases the volume of the dural sac. The latter becomes more distended with a consequent increase in both the CSF pressure and the venous pressure (the CSF pressure and the intradural venous pressure are identical). An appreciable increase in the venous pressure forces a collateral circulation to open up and the CSF pressure can reestablish. The significance of the epidural space lies in the presence of an extensive venous plexus which can easily compensate for changes in the volume of the dural sac.

IV. By means of quantitative analysis it could be demonstrated that the angles for the rise and fall of CSF pressure on jugular compression were fairly constant in normal subjects, and that the angle for CSF pressure fall was larger than for CSF pressure rise. The angle for CSF pressure fall appeared to be a more reliable indication of the presence of spinal subarachnoid obstruction than the angle for rise - a finding not recorded in the literature. Most obstructions were found upon performing Queckenstedt's test with the head in retroflexion. These findings indicate the importance of performing Queckenstedt's test with the head in retroflexion, and of paying close attention to the CSF pressure fall on release of jugular compression.

The various shapes of the CSF pressure changes upon jugular compression were separately classified for the rise and the fall of CSF pressure. Those designated as square and broken (Fig. 12) were regarded as normal, and all the others (convex, concave, straight, square concave, square straight and valve) as indicating obstruction of the spinal CSF pathways. Again, it was demonstrated that the shapes upon CSF pressure fall were the most sensitive. The authors classification of the various shapes proved helpful in the diagnosis of obstruction, and visual evaluation of CSF pressure curves - i.e. interpreting the CSF pressure tracings without mathematical analysis - sufficed for accurate diagnosis; more detailed study was shown to be superfluous. Following the withdrawal of 10 $cm.^3$ CSF, the results of jugular compression became unreliable: more abnormal shapes were encountered and the angles for CSF pressure rise and fall approximated the sharper angles seen in cases of spinal subarachnoid obstruction.

The amplitude of the cardiac pulsations is of significance in the appraisal of the CSF pressure recordings. The well-known observation that high CSF pressures are accompanied by cardiac pulsations of greater amplitude was confirmed by quantitative analysis. Furthermore, the relationship between the height of the CSF pressure and the pulse amplitude proved to be a linear one.

V. The clinical validity of the electromanometric method was found to be good, and apparently contradictory results in certain cases could be explained. However, its clinical usefulness is limited: electromanometry proved to be of diagnostic aid only in patients with cervical lesions, particularly in the differential diagnosis of intermittent obstruction (spondylotic myelopathy, pincer mechanism, narrow spinal canal). Also, it determined the choice of contrast medium to be used: subarachnoid obstruction - particularly the intermittent variety - is thought most amenable to study by positive-contrast myelography, because this medium permits functional myelographic examination of the subarachnoid space.

It seemed likely that in patients with a myelopathy due to cervical spondylosis (often in conjunction with a narrow spinal canal) treated by extensive laminectomy, the operative results were better if electromanometric examination had demonstrated a spinal subarachnoid obstruction. Whether or not this observation possesses any practical value will have to be evaluated in a larger series of cases.

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VI. Several other phenomena became apparent during this study of the CSF pressure curves. Respiratory fluctuations may vary, but the presence of Antoni's respiration sign of obstruction is of diagnostic significance. Changes in the cardiac rhythm should be recognized. The presence of contrast medium in the dural sac may lead to erroneous interpretations.

VII. Attention was paid to the effect of Valsalva's manoevre, i.e. straining, on the CSF pressure. In an appreciable number of instances a secondary pressure wave was observed following cessation of straining; its form proved to be fairly constant. The phenomenon of the secondary pressure wave could be related to the variations in cardiac minute volume. The occurrence of this secondary pressure wave was not confined to Valsalva's manoevre, it was also observed in certain individuals following jugular compression as a consequence of triggering a carotid sinus reflex.